

STUDY TITLE

Comments on Draft Water Quality Criteria Report for Bifenthrin Issued by the
California Regional Water Quality Control Board, Central Valley

DATA REQUIREMENTS

None

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COMPLETED ON

January 12, 2010

REPORTING FACILITY

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PROJECT IDENTIFICATION

CSI 10701
FMC Study Number: PC-0521

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Executive Summary

Draft water quality criteria reports for the pyrethroid insecticide bifenthrin and three other insecticides have been issued by the University of California, Davis (UCD) and are being circulated for public comment. Compliance Services International (CSI), Lakewood WA, has developed the comments presented herein on behalf of FMC Corporation, the registrant for bifenthrin. These comments address three main areas: data selection for derivation of Acute and Chronic Criteria; aspects of the UCD methodology; and bioavailability.

The data selected by UCD for derivation of the Acute Criterion for bifenthrin overlooked several Relevant and Reliable studies. Inclusion of these studies resulted in a recalculated Acute Criterion of 7 ng/L. (UCD's proposed Acute Criterion was 4 ng/L.)

Due to limited data available on chronic toxicity, an Acute-to-Chronic Ratio (ACR) approach was used to derive the Chronic Criterion for bifenthrin. Based on the default ACR of 12.4 and the recalculated acute value, the recalculated Chronic Criterion is 1 ng/L. (UCD's proposed Chronic Criterion was 0.3 ng/L.)

The UCD methodology for deriving numeric water quality criteria is generally sound, though some details of the data selection process could be improved. The ETX program is an appropriate tool for deriving an acute value; it has the advantages of being well-tested, standardized, and widely accepted throughout the world. Chronic values should be based on an ECx, not an MATC, because an ECx value represents a specific magnitude of effect, not simply statistical difference from controls.

Pyrethroids that are bound to particulate matter or associated with dissolved organic matter are not biologically available to aquatic organisms and do not contribute to toxicity; only freely dissolved pyrethroids are bioavailable and toxic. In laboratory toxicity tests using water with minimal particulate or dissolved organic matter, nearly all the pyrethroid is bioavailable. In ambient water, only a small fraction – a few percent or less – of the total pyrethroid may be bioavailable. Compliance with bifenthrin water quality standards should therefore be based on concentrations of freely dissolved bifenthrin, not total bifenthrin. Freely dissolved bifenthrin can be measured directly using solid phase microextraction (SPME), or calculated using an equilibrium partitioning model. Any water quality program should measure freely dissolved bifenthrin concentrations to ensure appropriate comparison to concentrations calculated as Acute or Chronic Criteria.

1. Introduction

As part of the Central Valley Pesticide TMDL and Basin Plan Amendment Project, draft water quality criteria for the pyrethroid insecticide bifenthrin and three other insecticides have been derived by the University of California, Davis (Palumbo *et al.* 2009) and are being circulated for public comment. Compliance Services International (CSI), Lakewood WA, has developed the comments presented below on behalf of FMC Corporation, the registrant for bifenthrin.

2. Derivation of Acute Criterion

UCD's draft Acute Criterion is based on data for 8 freshwater species, presented in Table 2 of their report. Toxicity values for several of these species require correction, as discussed below. Relevant and reliable data are also available for other species, and these affect the calculated acute value and the Acute Criterion. The aquatic toxicity data used by UCD and those proposed by CSI are summarized in Table 1. A full list of data, including some results not used or proposed for use in criteria derivation, is presented in Appendix A.

2.1 *Ceriodaphnia dubia*

UCD calculates the Acute Criterion using the *C. dubia* 96-h LC50 of 0.078 µg/L from a test by the California Department of Fish and Game (Guy 2000a). A 48-h LC50 from another study (Wheelock *et al.* 2004) was also rated "relevant and reliable" but the result was excluded in the data reduction process in favor of the 96-h value. We believe this exclusion was unwarranted, as discussed below. Two other studies (Yang *et al.* 2006 and Liu *et al.* 2005) were rated "relevant but less reliable" by UCD, presumably due to inadequate detail in the publications (UCD provided Data Evaluation Forms only for studies rated Relevant and Reliable). A 48-h EC50 from a fifth study (Mokry and Hoagland 1990) was for a formulated product and was rated "less relevant but reliable" by UCD.

The result from Wheelock *et al.* 2004 (48-h LC50 = 0.142 µg/L) was rated "RR" by UCD but was excluded in the data reduction process (see UCD's Table 3) with a footnote indicating the following reason: "A more sensitive or more appropriate test duration was available from the same test." However, there is no other result "from the same test." A 48-h exposure duration is standard for *C. dubia*. The species geometric mean of the two values (0.105 µg/L) is appropriate for use in deriving water quality criteria.

The results presented by Liu *et al.* (2005) are identical (to 2 significant figures) to those in Liu *et al.* (2004), and presumably come from the same test. Both publications report 96-h LC50 values for a bifenthrin enantiomer mix (racemate), corresponding to the commercial active ingredient, as well as for the 1*R*-cis isomer alone. The LC50 value cited by UCD, 0.079 µg/L, is for the 1*R*-cis isomer; the LC50 for the enantiomer mix is 0.144 µg/L. The water quality criteria for bifenthrin apply to the commercial enantiomer mix, not the single isomer, which is not the active ingredient in any registered pesticide product. The studies by Liu *et al.* (2005) and Yang *et al.* (2006) were rated "less reliable" by UCD. CSI notes that the methodology in these studies was strong but the documentation was incomplete, probably abbreviated in order to conform to the styles of the journals.

The UCD database did not include the GLP study by Hooftman *et al.* (2002) with *C. dubia* as well as 5 other invertebrate species. CSI evaluated this study using the TenBrook *et al.* (2009) criteria and rated it relevant and reliable. However, the 24-h exposure duration used in this study was less than the

standard 48-h exposure for *C. dubia*, so the result (24-h LC50 = 0.31) is less relevant than the 48-h and 96-h LC50 values from the other studies.

2.2 *Daphnia magna*

UCD derived the Acute Criterion using the *D. magna* 48-h EC50 of 1.6 µg/L from a GLP registration study (Surprenant 1983). Results are also available from 4 other GLP studies and 1 non-GLP study, as well as two studies with formulations. The additional 48-h and 96-h LC50 values range from 0.11 µg/L (Surprenant 1985a) to 0.99 µg/L (Brown 1980). Only Surprenant (1983) and Surprenant (1985a) used flow-through exposure. The geometric mean of these two EC50s, 0.42 µg/L, is the appropriate value to use for this species in deriving an Acute Criterion for bifenthrin.

2.3 *Hyalella azteca*

UCD presents LC50 data from two studies with *H. azteca*, including four tests by Weston and Jackson (2009) and one by Anderson *et al.* (2006). UCD's analysis used the geometric mean of the LC50 values from the five tests (0.0065 µg/L). If the two studies (rather than the five tests) were weighted equally in the analysis, the species geometric mean would be 0.0075 µg/L. We believe this value, with the two studies receiving equal weight, should be used in the calculation of Acute Criterion, though we acknowledge that the small difference in this case is unlikely to affect the result.

2.4 *Chironomus dilutus*

The 96-h LC50 for *C. dilutus* is shown as 26,150 ng/L (=26.15 µg/L) in the publication by Anderson *et al.* (2006). However, UCD notes that correspondence with the authors confirmed that the published value is in error, and the correct LC50 is 2.615 µg/L.

2.5 *Lepomis macrochirus*

UCD uses the 96-h LC50 of 0.35 µg/L reported by Hoberg (1983a) for *L. macrochirus*. Another relevant and reliable study (Surprenant 1985b) reported a 96-h LC50 of 0.26 µg/L. The species geometric mean, 0.30 µg/L, should be used in the calculation of the Acute Criterion.

2.6 *Oncorhynchus mykiss*

UCD uses the 96-h LC50 of 0.15 reported by Hoberg (1983b) for *O. mykiss*. Another relevant and reliable study (Surprenant 1985c) reported a 96-h LC50 of 0.1 µg/L. The species geometric mean, 0.12 µg/L, should be used in the calculation of the Acute Criterion.

2.7 Additional species

A study conducted under GLP by TNO Laboratories (Hooftman *et al.* 2002) was evaluated by CSI and rated relevant and reliable. The Study Evaluation Forms are presented in Appendix B. Results are available for four additional species, as follows:

Gammarus pulex: 48-h LC50 = 0.11 µg/L

Hexagenia sp.: 48-h LC50 = 0.39 µg/L

Thamnocephalus platyurus: 24-h LC50 = 5.7 µg/L

Note: the 24-h exposure is recommended for this species, according to study report.

Trichoptera (species unidentified): 48-h LC50 = 0.18 µg/L

Hooftman *et al.* also tested *C. dubia* (24-h EC50 = 0.142 µg/L) and *D. magna* (48-h EC50 = 0.37 µg/L). The 24-h exposure for *C. dubia* is less than the standard 48-h exposure for that species. The *D. magna* study was a static test. Both values were excluded by CSI during data reduction.

2.8 Calculation of Acute Criterion

The UCD report states that the ETX 2.0 software program (Van Vlaardingen *et al.* 2004) was used to fit the data set to a log-logistic distribution. UCD reported a median HC5 of 0.007460 µg/L. Using the same software and the data shown in UCD's Appendix B, CSI obtained a median HC5 value of 0.007694 µg/L, quite close to UCD's result. However, two of the data points in Appendix B differ from those shown in UCD's Table 2. First, Appendix B shows a value of 0.21 µg/L from McAllister (1988) for *Pimephales promelas*, rather than the species geometric mean of 0.405 µg/L for McAllister (1988) and Guy (2000b) as shown in Table 2. Second, Appendix B shows the value for *C. dubia* as 0.079 µg/L, not 0.078 µg/L as in Table 2 and in the original study report. Using UCD's final acute toxicity data as shown in their Table 2, CSI obtained a median HC5 value of 0.008068 µg/L (95% limits 0.0005-0.034 µg/L), corresponding to an Acute Criterion (acute value divided by 2, reported with one significant digit) of 4 ng/L, unchanged from UCD's recommended Acute Criterion.

As discussed above, CSI proposes corrections to UCD's toxicity values for *C. dubia*, *D. magna*, *H. azteca*, *L. macrochirus*, and *O. mykiss*. These proposed changes are summarized in Table 1. With these corrections, the median HC5 is calculated as 0.009860 µg/L (0.0008-0.036 µg/L) (Table 2). The Acute Criterion is 5 ng/L.

Taking into account the 4 additional species reported by Hooftman *et al.* (2002) as well as the corrections for the five other species, the HC5 for bifenthrin is 0.013968 µg/L (0.0024-0.041). This is the most appropriate estimate of the HC5, because it incorporates all available data from studies rated Relevant and Reliable. The corresponding Acute Criterion is 7 ng/L.

The study of Siegfried (1993) included acute toxicity data for 5 other species, but was incompletely documented and was therefore rated "less reliable" by both UCD and CSI. If these species were included in the analysis, the HC5 for bifenthrin would be 0.022469 µg/L (0.0051-0.060), and the Acute Criterion would be 11 ng/L. However, given the age of the study, it is unlikely that the missing elements of the documentation could be obtained to raise the study rating to Reliable, so the data cannot properly be used in derivation of the Acute Criterion.

Conclusion on Acute Criterion

- UCD's draft Acute Criterion for bifenthrin was 4 ng/L. This result was based on toxicity values for two species that differed from those in UCD's Final Acute Toxicity Data Set (their Table 2), but the Acute Criterion was unaffected by these discrepancies.
- CSI proposes corrections to the values used for *Ceriodaphnia dubia*, *Daphnia magna*, *Hyalella azteca*, *Lepomis macrochirus*, and *Oncorhynchus mykiss*. Based on these corrected values, the Acute Criterion for bifenthrin is 5 ng/L.
- Data for 4 additional species are available from a relevant, reliable study that was not considered by UCD. When these data are included in the analysis, the Acute Criterion for bifenthrin is 7 ng/L. This is the value recommended by CSI.
- Data for 5 additional species are available from another relevant but less reliable study. If these data were included in the analysis, the Acute Criterion for bifenthrin would be 12 ng/L. However, unless the study can be upgraded to a rating of Reliable (through communication with the author, for example), these additional data cannot be used.

3. Derivation of Chronic Criterion

UCD's draft bifenthrin criteria document discussed chronic toxicity data for *Daphnia magna* and *Pimephales promelas* (Table 1). For *D. magna* UCD used the 21-d MATC of 0.0019 µg/L from a study by Burgess (1989). Two other available studies were not included in UCD's dataset: Hoberg *et al.* (1995) and Wang *et al.* (2009). CSI evaluated these studies using the UCD methodology (TenBrook *et al.* 2009) and rated them Relevant and Reliable (Rating Forms are presented in Appendix B). The geometric mean of the three MATC values is 0.0034 µg/L. A chronic test with *Oncorhynchus mykiss* was also available (Surprenant and Yarko 1985). Chronic toxicity data are also available for *Americamysis bahia* (formerly *Mysidopsis bahia*), a marine invertebrate (Boeri and Ward 1991; Ward and Boeri 1991); UCD rated these studies Less Relevant (because of the marine test species) but Reliable.

Derivation of a chronic criterion using the SSD approach would have required, in addition to the species listed above, data on toxicity to a benthic invertebrate and an aquatic insect. EPA's Acute-to-Chronic Estimator (ACE) program is intended to generate chronic toxicity values for this purpose (TenBrook *et al.* 2009), but UCD did not use ACE, "to avoid excessive layers of estimation." Instead, UCD applied an Acute-to-Chronic Ratio (ACR) approach. Since none of the available chronic toxicity values is matched by an acute toxicity value meeting the criteria outlined in Section 3-4.2.1 of TenBrook *et al.* (2009), the default ACR value of 12.4 was used.

As discussed in Section 2.8, the acute toxicity value (HC5) derived based on CSI's amended dataset is 0.013968 µg/L. Applying the default ACR, the Chronic Criterion is 0.0011 µg/L, or 1 ng/L. This value is approximately a factor of 3 below the lowest acceptable chronic value of 3.4 ng/L for *Daphnia magna*.

4. Methodology for Deriving Criteria

The nature, purpose, and limitations of numerically derived water quality criteria are clearly stated by TenBrook *et al.* (2009, Section 3-1.2): "Numeric criteria are science-based values, which are intended to protect aquatic life from adverse effects of pesticides, without consideration of defined water body

uses, societal values, economics, or other nonscientific considerations. Criteria and guidelines are not formally established, nor are they themselves water quality objectives. Criteria derived using this method do not represent CVRWQCB policy and are not regulations. Also, while this method uses data from the pesticide registration process, the method is not intended to replace the risk assessment work performed by the pesticide regulatory agencies.”

Certain generic aspects of the methodology used to derive the bifenthrin criteria are discussed below.

4.1 Data collection

The goal of data collection is stated as “to find virtually all available physical-chemical and ecotoxicity data for a given pesticide” (TenBrook *et al.* 2009, Section 3-2.1). “Only data for freshwater species that are members of families with reproducing populations in North America will be used for criteria derivation, but all data should be collected as it may be used for supporting information or for derivation of an acute-to-chronic ratio (ACR).” This restriction is unnecessary, because toxicity test species are surrogates for all species, and there is no indication that species from North American families are better surrogates than species from families that do not occur in North America.

TenBrook *et al.* (2009, Section 3-2.1) note that “data from agencies [i.e., GLP studies submitted to agencies by registrants] can make up most of the high quality toxicity studies available, especially for compounds with limited data.” We agree with this generalization. The deficiencies of academic studies published in the open literature are generally of two kinds: use of non-standard test protocols, and failure to report data critical to evaluation of study acceptability. This issue is further discussed in Section 4.2 below.

TenBrook *et al.* (2009, Section 3-2.1.1.2) state, “For derivation of chronic criteria or acute-to-chronic ratios, obtain maximum acceptable toxicant concentrations (MATCs). Chronic data expressed as EC_x values (from regression analysis), may be used for criteria derivation only if studies are available to show what level of *x* is appropriate to represent a no-effect level.” However, use of the MATC does not address the question of determining an appropriate value of *x*; the MATC is based on determinations of statistical significance, regardless of biological significance or magnitude of effect. An MATC can be associated with a wide range of EC_x values depending on the nature of the measurement endpoint and the variability of the measurements. We believe it is better to establish (as a matter of policy grounded in science) a tolerable level of effect for a particular species and endpoint, and use concentration-effect models (e.g., regression analysis) to estimate the concentration corresponding to that level of effect, i.e., the EC_x.

4.2 Data evaluation

The UCD methodology calls for an evaluation of the data for relevance first, and for reliability only if the relevance score is 70 or greater. This tiered approach makes data selection more efficient, because a relevance evaluation can usually be done very quickly and no further time needs to be invested in evaluating the reliability of an irrelevant study.

For relevant studies, the recommended process is to extract information to data sheets, and use the results to evaluate reliability according to the rating systems shown in Tables 3.7 and 3.8 of TenBrook *et*

al. (2009). While the data extraction process (using the forms provided) can be cumbersome, it is objective and reasonably complete, and does provide a good basis for evaluating data reliability and documenting the evaluation.

Two categories of reliability criteria are used: Documentation and Acceptability. Many criteria in the two groups are related. For example, failure to report dissolved oxygen concentrations results in loss of 4 points for Documentation, and inability to confirm that dissolved oxygen concentrations were acceptable results in loss of 6 points for Acceptability. Thus, a peer-reviewed open-literature publication that fails to report dissolved oxygen concentrations has already lost 10 points (out of 200) in its Reliability score. Failure to report pH, hardness, alkalinity, and conductivity results in loss of 16 more points. These water quality variables are needed only to confirm that the test was run under acceptable conditions – they generally do not affect the outcome of the test – yet their omission from a publication results in a substantially reduced reliability rating.

Similar reporting deficiencies (not uncommon in journal articles, where words are often at a premium) can result in a perfectly sound toxicity test receiving a rating of “Less Reliable.” In contrast, because of the data reporting requirements for regulatory studies and the requirements of Good Laboratory Practices, studies submitted by registrants are nearly always “Reliable.”

An unavoidable consequence of the reliability evaluation is that standard studies, many of which test species that are known to be highly sensitive to pesticides (e.g., daphnids, mysid shrimp, amphipods, and salmonid fish), are more likely to be included in criteria derivation than studies on non-standard species. In CSI’s evaluation of the acute toxicity data for bifenthrin (Section 2), addition of data on non-standard (and generally less sensitive) species was seen to result in a substantial increase in the derived Acute Criterion (Table 2). The use of sensitive species in standard toxicity tests therefore results in additional conservatism of the derived criteria.

4.3 Acute Criterion derivation using SSD

The UCD methodology (TenBrook *et al.* 2009) requires data for at least 5 species representing at least the following 5 groups: the family Salmonidae, a warm water fish (e.g. bluegill sunfish, fathead minnow), a planktonic crustacean – at least one from the family Daphniidae (e.g. *Daphnia magna*, *Ceriodaphnia dubia*), a benthic crustacean (e.g., *Hyalella azteca*, *Gammarus pulex*), and an aquatic insect (e.g., *Chironomus dilutus*). UCD’s acute dataset for bifenthrin, with 8 species, fulfilled all five categories.

TenBrook *et al.* (2009) provide detailed statistical guidance for SSD analysis, but recommend using a program such as the ETX program (Van Vlaardingen *et al.* 2004) to derive the Acute Criterion. ETX is one of many tools and methods available for estimating the 5th percentile of the SSD; it has the advantages of being well-tested, standardized, and widely accepted throughout the world. Use of ETX avoids controversy about the suitability of the statistical methods used to derive the criteria.

4.4 Chronic Criterion derivation

Deriving a Chronic Criterion using the SSD approach requires MATC values for at least five species from the same categories as the acute criterion. Reasons for using ECx values rather than MATCs were

presented above (Section 4.1), though we acknowledge the lack of agreement about what x should be for a particular taxon and endpoint.

If chronic data are insufficient for an SSD approach, an ACR approach is used (TenBrook *et al.* 2009, Section 3-4.2). At first, TenBrook *et al.* (2009, Section 3-4.2.1) seem to require that the acute and chronic data used to calculate an ACR must come from the same study in the same dilution water, but then this requirement is relaxed to allow a different study in the same laboratory under identical conditions, or even in a different laboratory – in other words, only the dilution water must be the same. The rationale for this requirement is unclear, since toxicity values are not presumed to be strongly affected by the source of dilution water.

ACRs are required for three species, including a fish and an invertebrate. If there are insufficient data, a default ACR of 12.4 is used for one or more of these species. The default ACR (TenBrook *et al.* 2009, Section 3-4.2.3) is the 80th percentile value derived from ACRs for 8 insecticides (chlordane, chlorpyrifos, diazinon, dieldrin, endosulfan, endrin, lindane, and parathion). TenBrook *et al.* (2009) do not explain why these insecticides should be considered representative of pesticides from different chemical groups, or why the 80th percentile should be used as the basis for a default ACR.

5. Bioavailability of Bifenthrin

The draft criteria report summarizes evidence that pyrethroids bound to particulate matter are not biologically available to aquatic organisms and do not contribute to toxicity; only freely dissolved pyrethroids are bioavailable and toxic. Bound pyrethroids become bioavailable only when they desorb from particles or dissociate from dissolved organic matter.

The UCD report notes the possibility that pyrethroids can be taken up from ingested particles, citing the findings of Mayer *et al.* (2001) as evidence that hydrophobic compounds can be desorbed by digestive juices. The cited study involved uptake of benzo(a)pyrene and zinc by 18 species of benthic marine invertebrates, including 10 species of worms, 5 species of echinoderms, 2 species of mollusks, and a sea anemone. The relevance of these findings to uptake of pyrethroids by sensitive freshwater taxa (such as insects and crustaceans) is unclear. There is no evidence for uptake of pyrethroids by this route, and the UCD report in fact summarizes the evidence to the contrary.

TenBrook *et al.* (2009, Section 3-5.1) state that when a pesticide has only a single bioavailable phase (sorbed to solids, associated with dissolved organic matter, or freely dissolved in water), it is appropriate to evaluate compliance with water quality standards based on concentrations in the bioavailable phase alone. This is the case for bifenthrin and other pyrethroids, of which only the freely dissolved phase is bioavailable. Pyrethroid concentrations in the freely dissolved phase can be measured using techniques such as solid-phase microextraction (SPME), or calculated based on partitioning coefficients (Equation 3.6, TenBrook *et al.* 2009). The equilibrium partitioning model requires input values for dissolved and particulate organic carbon (OC); UCD considers these values to be site-specific properties that are “laborious” to measure. CSI disagrees: measurement of dissolved and particulate organic carbon and total suspended solids is not particularly difficult (compared to analysis of bifenthrin, for example) and is useful for calculation of freely dissolved lipophilic chemicals. The US EPA uses equilibrium partitioning models to estimate freely dissolved concentrations of pyrethroids in sediment pore water, based on

measured or default values for dissolved and particulate organic carbon concentrations (e.g., USEPA 2005).

In laboratory toxicity tests using low-particulate, low-OC water as the exposure medium, pyrethroids are much more bioavailable than in water with natural levels of particulates and OC. Because aquatic toxicity test guidelines require the use of water containing minimal amounts of particulate matter and dissolved organic carbon, bioavailability is not a significant factor under standard test conditions. In ambient water, however, analysis of total pyrethroid is liable to overestimate the bioavailable concentration by at least an order of magnitude. For these reasons, we believe that evaluation of water quality compliance for pyrethroids should be based on measured or calculated concentrations of freely dissolved pyrethroid, consistent with the recommendations of TenBrook *et al.* (2009, Section 3-5.1).

UCD concludes that that laboratory toxicity data based on nominal whole-water concentrations are likely to overestimate freely dissolved pyrethroid, citing one test with only 30% recovery of added bifenthrin. This is an extreme example. Most measured concentrations in the bifenthrin studies used in this analysis (those rated Relevant and Reliable) are much closer to nominal values (Table 3), and do not support UCD's contention that toxicity values based on nominal concentrations greatly underestimate the toxicity of the freely dissolved fraction. As discussed above, nearly all of the bifenthrin present in toxicity test solutions is likely to be freely dissolved and bioavailable.

UCD also cites an example from a spiked sediment study with *Chironomus dilutus* (Xu *et al.* 2007), in which total concentrations in pore water were more than an order of magnitude higher than freely dissolved concentrations measured using SPME. This is not unexpected in sediment toxicity tests, due to the presence of dissolved organic carbon (and possibly residual particles, depending on the efficiency of centrifugation) in the pore water. The situation is much different in water-only toxicity tests, in which dissolved and particulate matter are kept to a minimum and most of the pesticide is bioavailable.

We therefore do not concur with UCD's recommendation that criteria compliance be based on whole-water bifenthrin concentrations, without consideration of bioavailability. UCD concedes that use of whole-water concentrations is likely to be overprotective, but accepts such overprotection as "compensating for the use of nominal concentrations and unknown effects of dietary exposure." Since the bioavailable fraction may be on the order of a few percent or less of the whole-water bifenthrin concentration, the overprotection that would be incurred by basing compliance on whole-water concentrations greatly outweighs the potential underprotection (a factor of 2 or 3 at most) caused by use of nominal concentrations. UCD suggests that this recommendation should be revised when more toxicity data based on measured concentrations are available. We note that measured concentrations are already available for 20 of the 25 Relevant and Reliable studies listed in Table 3.

6. Conclusions

- The data selected by UCD for derivation of the Acute Criterion for bifenthrin overlooked several Relevant and Reliable studies. Inclusion of these studies resulted in a recalculated Acute Criterion of 7 ng/L. (UCD's recommended Acute Criterion was 4 ng/L.)
- Due to limited data available on chronic toxicity, an Acute-to-Chronic Ratio (ACR) approach was used to derive the Chronic Criterion for bifenthrin. Based on the default ACR of 12.4 and the

recalculated acute value, the recalculated Chronic Criterion is 1 ng/L. (UCD's recommended Chronic Criterion was 0.3 ng/L.)

- The UCD methodology for deriving numeric water quality criteria (TenBrook *et al.* 2009) is generally sound, though some details of the data selection process could be improved.
- The data evaluation criteria favor studies conducted by pesticide registrants following standard test guidelines and Good Laboratory Practices. Non-guideline studies reported in the open literature, which are the source of most data on non-standard species, are more likely to fail the reliability evaluation. Failures are mainly due to non-standard test protocols and deficiencies in reporting, not to unreliable results. The SSD approach requires data for as many species as possible, and too-stringent evaluation criteria may severely limit its applicability.
- Many standard tests involve sensitive test species such as daphnids, amphipods, and rainbow trout. As a result, Species Sensitivity Distributions (SSD) based mainly on data from standard tests tend to be biased toward sensitive species. In the case of bifenthrin, the 5th percentile (HC5) of the SSD increased when more non-standard species were included in the analysis. Even with these additional species, the bifenthrin SSD included no data for freshwater mollusks, a major aquatic group that is known to be insensitive to pyrethroids.
- The ETX program (Van Vlaardingen *et al.* 2004) is an appropriate tool for deriving an acute value (median value of the 5th percentile, or HC5) from an SSD. It has the advantages of being well-tested, standardized, and widely accepted throughout the world.
- For derivation of Chronic Criteria, ECx values are preferable to MATCs. An MATC simply reflects a determination of statistical significance, regardless of biological significance or magnitude of effect. An ECx represents a specific magnitude of effect. Appropriate values of x have not yet been agreed upon, but they should be selected with biological significance in mind.
- Pyrethroids bound to particulate matter or associated with dissolved organic matter are not biologically available to aquatic organisms and do not contribute to toxicity; only freely dissolved pyrethroids are bioavailable and toxic. In laboratory toxicity tests using water with minimal particulate or dissolved organic matter, nearly all the pyrethroid is bioavailable. In ambient water, only a small fraction – a few percent or less – of the total pyrethroid may be bioavailable. Compliance with bifenthrin water quality standards should therefore be based on concentrations of freely dissolved bifenthrin, not total bifenthrin. Freely dissolved bifenthrin can be measured directly using solid phase microextraction (SPME), or estimated using an equilibrium partitioning model such as the one presented by Tenbrook *et al.* (2009).

7. References

Anderson BS, Phillips MB, Hunt JW, Connor V, Richard N, Tjeerdema RS. 2006. Identifying primary stressors impacting macroinvertebrates in the Salinas River (CA, USA): Relative effects of pesticide and suspended particles. *Environ Pollut* 141:402-408.

Barrows ME. 1986a. Acute toxicity of FMC 54800 to sheepshead minnow (*Cyprinodon variegatus*). Battelle, Duxbury, MA. FMC Study No. A1985-1874.

Barrows ME. 1986b. Acute toxicity of FMC 54800 to mysid shrimp *Mysidopsis bahia*. Battelle, Duxbury, MA. FMC Study No. A1985-1875.

Boeri RL, Ward TJ. 1991 Life cycle toxicity of bifenthrin (FMC 54800) to the mysid, *Mysidopsis bahia*. FMC Study No. A1990-3318.

Browne A. 1980. The acute toxicity of FMC 54800 to the water flea *Daphnia magna* Straus. Union Carbide Study 11506-07-40. FMC Study No. A1979-349.

Burgess D. 1989. Chronic toxicity of 14C-FMC 54800 to *Daphnia magna* under flow-through conditions. ABC Report No. 36980. FMC Study No. A1988-2649.

Guy D. 2000a. Bifenthrin with cladocerans *Ceriodaphnia dubia* in an acute definitive test. Aquatic Toxicology Laboratory Report P-2161-2. California Fish and Game, Aquatic Toxicology Lab, Elk Grove, CA.

Guy D. 2000b. Bifenthrin with *Pimephales promelas* in an acute definitive test. Aquatic Toxicology Laboratory Report P-2161-1. California Fish and Game, Aquatic Toxicology Lab, Elk Grove, CA.

Handley JW, Grant-Salmon D, Bartlett AJ. 1992a. The acute toxicity of Talstart 80 g/L flowable formulation to *Daphnia magna*. Safepharm Laboratories Project No. 240-70. FMC Study No. A2003-5652.

Handley JW, Grant-Salmon D, Bartlett AJ. 1992b. The acute toxicity of Talstart 80 g/L flowable formulation to rainbow trout (*Oncorhynchus mykiss*). Safepharm Laboratories Project No. 240-71. FMC Study No. A2003-5620.

Hoberg JR. 1983a. Acute toxicity of FMC 54800 technical to bluegill (*Lepomis macrochirus*). EG&G Bionomics Report BW-83-8-1445. EG&G Bionomics, Wareham, MA. FMC Study No. A1983-0987.

Hoberg JR. 1993b. Acute toxicity of FMC 54800 technical to rainbow trout (*Salmo gairdneri*). EG&G Bionomics Report BW-83-8-1446. EG&G Bionomics, Wareham, MA. FMC Study No. A1983-0967.

Hoberg JR, Nicholson RB, Grandy K, Surprenant DC. 1985. The chronic toxicity of 14C-FMC 54800 to *Daphnia magna* under flow-through conditions. Springborn Bionomics Report BW-85-3-1747. Springborn Bionomics, Wareham, MA. FMC Study No. A1984-1256.

Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands. FMC Study No. A2003-5701.

Liu W, Gan J, Schlenk D, Jury WA. 2004. Enantioselectivity in environmental safety of current chiral insecticides. *Proc Nat Acad Sci* 102:701-706.

Liu W, Gan J, Lee S, Werner I. 2005. Isomer selectivity in aquatic toxicity and biodegradation of bifenthrin and permethrin. *Environ Toxicol Chem* 24:1861-1866.

McAllister WA. 1988. Full life cycle toxicity of 14C-FMC54800 to the fathead minnow (*Pimephales promelas*) in a flow-through system. FMC Study No. A1986-2100.

Mokry LE, Hoagland KD. 1990. Acute toxicities of five synthetic pyrethroid insecticides to *Daphnia magna* and *Ceriodaphnia dubia*. *Environ Toxicol Chem* 9:1045-1051.

Palumbo AJ, Fojut TL, Tjeerdema RS. 2009. Bifenthrin Criteria Derivation Draft. Univ. California – Davis. Report prepared for the Central Valley Regional Water Quality Control Board, Rancho Cordova, CA.

Siegfried BD. 1993. Comparative toxicity of pyrethroid insecticides to terrestrial and aquatic insects. *Environ Toxicol Chem* 12:1683-1689.

Surprenant DC. 1983. Acute toxicity of FMC 54800 technical to *Daphnia magna*. EG&G Bionomics Report BW-83-8-1444. EG&G Bionomics, Wareham, MA. FMC Study No. A1983-0986.

Surprenant DC. 1985a. Acute toxicity of 14C-FMC 54800 to *Daphnia magna* under flow-through conditions. Springborn Bionomics Report BW-85-2-1731. Springborn Bionomics, Wareham, MA. FMC Study No. A1984-1404.

Surprenant DC. 1985b. Acute toxicity of 14C-FMC-54800 to bluegill (*Lepomis macrochirus*) under flow-through conditions. Springborn Bionomics Report BW-85-2-1730. Springborn Bionomics, Wareham, MA. FMC Study No. A1984-1402.

Surprenant DC. 1985c. Acute toxicity of 14C-FMC-54800 to rainbow trout (*Salmo gairdneri*) under flow-through conditions. Springborn Bionomics Report BW-85-2-1732. Springborn Bionomics, Wareham, MA. FMC Study No. A1984-1403.

Surprenant DC, Yarko JC. 1985. The toxicity of 14C-FMC 54800 to rainbow trout (*Salmo gairdneri*) embryos and larvae. Springborn Bionomics Report BW-85-4-1766. Springborn Bionomics, Wareham, MA. FMC Study No. A1984-1254.

TenBrook PL, Palumbo AJ, Fojut TL, Tjeerdema RS, Hann P, Karkoski J. 2009. Methodology for derivation of pesticide water quality criteria for the protection of aquatic life in the Sacramento and San Joaquin River Basins. Phase II: methodology development and derivation of chlorpyrifos criteria. Report prepared for the Central Valley Regional Water Quality Control Board, Rancho Cordova, CA.

Thompson RS. 1985. FMC 54800 10 EC: determination of the acute toxicity to rainbow trout (*Salmo gairdneri*). FMC Study No. A2003-5699 / A1988-2695.

USEPA. 2005. Preliminary environment fate and effects assessment science chapter for the Reregistration Eligibility Decision of cypermethrin. United States Environmental Protection Agency, Washington, DC. October 25, 2005.

Van Vlaardingen PLA, Traas TP, Wintersen AM, Aldenberg T. 2004. ETX 2.0. A program to calculate hazardous concentrations and fraction affected, based on normally distributed toxicity data. Report No. 601501028/2004. National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands.

Wang C, Chen F, Zhang Q, Fang Z. 2009. Chronic toxicity and cytotoxicity of synthetic pyrethroid insecticide *cis*-bifenthrin. *J Environ Sci* 21:1710-1715.

Ward GS. 1986a. Acute toxicity of FMC 54800 technical on shell growth of the eastern oyster (*Crassostrea virginica*). ESE Project No. 85-322-0950-2130. Environmental Science and Engineering, Gainseville, FL. FMC Study No. A1986-2083.

Ward GS. 1986b. Acute toxicity of FMC 54800 technical on new shell growth of the eastern oyster (*Crassostrea virginica*). ESE Project No. 85-322-0960-2130. Environmental Science and Engineering, Gainseville, FL. FMC Study No. A1986-2203.

Ward GS. 1987. Acute toxicity of FMC 54800 technical to embryos and larvae of the eastern oyster (*Crassostrea virginica*). ESE Project No. 87-318-0200-2130. Environmental Science and Engineering, Gainseville, FL. FMC Study No. A1987-2264.

Ward TJ, Boeri RL. 1991 Life cycle toxicity of bifenthrin (FMC 54800) to the mysid, *Mysidopsis bahia*. Envirosystems Study No. 9080-FMC. FMC Study No. A1990-3267.

Weston DP, Jackson CJ. 2009. Use of engineered enzymes to identify organophosphate and pyrethroid-related toxicity in toxicity identification evaluations. *Environ Sci Technol* 43:5514-5520.

Wheelock CE, Miller JL, Miller MJ, Gee SJ, Shan G, Hammock BD. 2004. Development of toxicity identification evaluation procedures for pyrethroid detection using esterase activity. *Environ Toxicol Chem* 23:2699-2708.

Williams TD. 1985. FMC 54800 10EC: Determination of the acute toxicity to *Daphnia magna*. ICI Brixham Study No. BL/B/2641. FMC Study No. A1988-2696.

Xu YP, Spurlock F, Wang ZJ, Gan J. 2007. Comparison of five methods for measuring sediment toxicity of hydrophobic contaminants. *Environ Sci Technol* 41:8394-8399.

Yang W, Spurlock F, Liu W, Gan J. 2006. Inhibition of aquatic toxicity of pyrethroid insecticides by suspended sediment. *Environ Toxicol Chem*. 25:1913-1919.

Table 1. Summary of bifenthrin aquatic toxicity data endpoints used to derive criteria.

Species	Endpoint	UCD Conc (µg/L)	Reference	CSI Proposed	Reference
ACUTE TOXICITY					
<i>Ceriodaphnia dubia</i>	96h LC50	0.078	Guy 2000a	0.105	Geomean: Guy 2000a, Wheelock <i>et al.</i> 2004
<i>Chironomus dilutus</i>	96h LC50	2.615	Anderson <i>et al.</i> 2006	2.615	Anderson <i>et al.</i> 2006
<i>Daphnia magna</i>	48h EC50	1.6	Surprenant 1983	0.42	Geomean: Surprenant 1983, Surprenant 1985a
<i>Hyalella azteca</i>	96h LC50	0.0065	Geomean: Weston & Jackson 2009, Anderson <i>et al.</i> 2006 (N=5)	0.0075	Geomean: Weston & Jackson 2009, Anderson <i>et al.</i> 2006 (N=2)
<i>Lepomis macrochirus</i>	96h LC50	0.35	Hoberg 1983a	0.30	Geomean: Hoberg 1983a, Surprenant 1985b
<i>Oncorhynchus mykiss</i>	96h LC50	0.15	Hoberg 1983b	0.12	Geomean: Hoberg 1983b, Surprenant 1985c
<i>Pimephales promelas</i>	96h LC50	0.405	Geomean: McAllister 1988 and Guy 2000b	0.405	Geomean: McAllister 1988, Guy 2000b
<i>Procladius sp.</i>	48h LC50	0.0843	Anderson <i>et al.</i> 2006	0.0843	Anderson <i>et al.</i> 2006
<i>Gammarus pulex</i>	48h LC50	—	—	0.11	Hooftman <i>et al.</i> 2002
<i>Hexagenia sp.</i>	48h LC50	—	—	0.39	Hooftman <i>et al.</i> 2002
<i>Thamnocephalus platyurus</i>	24h LC50	—	—	5.7	Hooftman <i>et al.</i> 2002
Trichoptera	48h LC50	—	—	0.18	Hooftman <i>et al.</i> 2002
<i>Enallagma/Ishnura</i>	24h LC50	(1.1)	Siegfried 1993 ^a	(1.1)	Siegfried 1993 ^a
Heptageniidae	24h LC50	(2.3)	Siegfried 1993 ^a	(2.3)	Siegfried 1993 ^a
<i>Hydrophilus</i> spp.	24h LC50	(5.4)	Siegfried 1993 ^a	(5.4)	Siegfried 1993 ^a
<i>Hydropsyche/Cheumatopsyche</i>	24h LC50	(7.2)	Siegfried 1993 ^a	(7.2)	Siegfried 1993 ^a
<i>Simulium vittatum</i>	24h LC50	(1.3)	Siegfried 1993 ^a	(1.3)	Siegfried 1993 ^a
CHRONIC TOXICITY					
<i>Daphnia magna</i>	21d MATC	0.0019	Burgess 1989	0.0034	Geomean: Burgess 1989, Hoberg <i>et al.</i> 1985, Wang <i>et al.</i> 2009
<i>Oncorhynchus mykiss</i>	76d MATC	—	—	0.019	Surprenant and Yarko 1985
<i>Pimephales promelas</i>	92d MATC	0.06	McAllister 1988	0.06	McAllister 1988

^aRated “less reliable” by UCD and CSI, not confirmed for use in derivation of criteria.

Table 2. Summary of acute HC5 values and corresponding Acute Criterion values based on alternative data selections.

Data Selection	Acute Value, HC5 (Confidence Interval)	Acute Criterion
UCD (Appendix B data, and text)	0.007460 µg/L	4 ng/L
UCD (Table 2 data)	0.008068 µg/L (0.0005-0.034 µg/L)	4 ng/L
UCD with CSI revisions (<i>C. dubia</i> , <i>D. magna</i> , <i>H. azteca</i> , <i>L. macrochirus</i> , <i>O. mykiss</i>)	0.009860 µg/L (0.0008-0.036 µg/L)	5 ng/L
UCD with CSI revisions plus 4 additional species reported by Hooftman (2002)	0.013968 µg/L (0.0024-0.041 µg/L)	7 ng/L

Table 3. Measured bifenthrin concentrations in toxicity tests rated Relevant and Reliable, as a percentage of nominal concentrations.

Species	Endpoint	Reference	Measured, % of nominal
<i>Ceriodaphnia dubia</i>	96h LC50	Guy 2000a	85%
<i>Ceriodaphnia dubia</i>	48h EC50	Wheelock <i>et al.</i> 2004	Not measured
<i>Ceriodaphnia dubia</i>	24h LC50	Hooftman <i>et al.</i> 2002	77 (62-89) %
<i>Chironomus dilutus</i>	96h LC50	Anderson <i>et al.</i> 2006	36-65%
<i>Daphnia magna</i>	21d MATC	Hoberg <i>et al.</i> 1985	54 (38-78) %
<i>Daphnia magna</i>	21d MATC	Burgess 1989	50-76%
<i>Daphnia magna</i>	21d MATC	Wang <i>et al.</i> 2009	Not measured
<i>Daphnia magna</i>	48h LC50	Surprenant 1985a	79 (69-89) %
<i>Daphnia magna</i>	48h EC50	Hooftman <i>et al.</i> 2002	105 (98-112) %
<i>Daphnia magna</i>	48h EC50	Surprenant 1983	Not measured
<i>Gammarus pulex</i>	48h LC50	Hooftman <i>et al.</i> 2002	80%
<i>Hexagenia</i> sp.	48h LC50	Hooftman <i>et al.</i> 2002	71 (59-86) %
<i>Hyalella azteca</i>	96h LC50	Weston & Jackson 2009	114 (64-189) %
<i>Hyalella azteca</i>	96h LC50	Anderson <i>et al.</i> 2006	19-56%
<i>Lepomis macrochirus</i>	96h LC50	Surprenant 1985b	101 (76-142) %
<i>Lepomis macrochirus</i>	96h LC50	Hoberg 1983a	Not measured
<i>Oncorhynchus mykiss</i>	76d MATC	Surprenant & Yarko 1985	87 (67-107) %
<i>Oncorhynchus mykiss</i>	96h LC50	Surprenant 1985c	100 (56-145%)
<i>Oncorhynchus mykiss</i>	96h LC50	Hoberg 1983b	Not measured
<i>Pimephales promelas</i>	92d MATC	McAllister 1988	53-146%
<i>Pimephales promelas</i>	96h LC50	McAllister 1988	73-88%
<i>Pimephales promelas</i>	96h LC50	Guy 2000b	184-204%
<i>Proclonus</i> sp.	48h LC50	Anderson <i>et al.</i> 2006	55-77%
<i>Thamnocephalus platyurus</i>	24h LC50	Hooftman <i>et al.</i> 2002	105 (83-120) %
Trichoptera	48h LC50	Hooftman <i>et al.</i> 2002	81 (77-86) %

Appendix A. Summary of aquatic toxicity data for bifenthrin.

Species	Endpoint	Conc (µg/L)	Reference	Rating	Rated by
<i>Americamysis bahia</i>	28d MATC	0.0012	Boeri and Ward 1991	LR (3)	UCD
<i>Americamysis bahia</i>	28d MATC	0.0025	Ward and Boeri 1991	LR (2,3)	UCD
<i>Americamysis bahia</i>	96h LC50	0.00397	Barrows 1986b	LR (3)	UCD
<i>Ceriodaphnia dubia</i>	96h LC50	0.05	Yang <i>et al.</i> 2006	RL (5)	UCD
<i>Ceriodaphnia dubia</i>	48h EC50	0.07	Mokry and Hoagland 1990	LR (1)	UCD
<i>Ceriodaphnia dubia</i>	96h LC50	0.078	Guy 2000a	RR	UCD
<i>Ceriodaphnia dubia</i>	96h LC50	0.079	Liu <i>et al.</i> 2005	RL (2,5)	UCD
<i>Ceriodaphnia dubia</i>	48h EC50	0.142	Wheelock <i>et al.</i> 2004	RR	UCD
<i>Ceriodaphnia dubia</i>	96h LC50	0.144	Liu <i>et al.</i> 2004	RL (5)	CSI
<i>Ceriodaphnia dubia</i>	24h LC50	0.31	Hooftman <i>et al.</i> 2002	RR	CSI
<i>Chironomus dilutus</i>	96h LC50	2.615	Anderson <i>et al.</i> 2006	RR	UCD
<i>Crassostrea virginica</i>	96h EC50	>2.15	Ward 1986a	LR (3,4)	UCD
<i>Crassostrea virginica</i>	96h EC50	>99.7	Ward 1986b	LR (3,4)	UCD
<i>Crassostrea virginica</i>	48h EC50	285	Ward 1987	LR (3)	CSI
<i>Cyprinodon variegatus</i>	96h LC50	17.8	Barrows 1986a	LR (3)	UCD
<i>Daphnia magna</i>	21d MATC	0.0015	Hoberg <i>et al.</i> 1985	LR (1) RR	UCD CSI
<i>Daphnia magna</i>	21d MATC	0.0019	Burgess 1989	RR	UCD
<i>Daphnia magna</i>	21d MATC	0.014	Wang <i>et al.</i> 2009	RR	CSI
<i>Daphnia magna</i>	48h EC50	0.11	Hoberg <i>et al.</i> 1985	LR (1)	UCD
<i>Daphnia magna</i>	48h LC50	0.11	Surprenant 1985a	RR	CSI
<i>Daphnia magna</i>	48h EC50	0.165	Williams 1985	LR (1)	CSI
<i>Daphnia magna</i>	96h LC50	0.175	Liu <i>et al.</i> 2004	RL (5)	CSI
<i>Daphnia magna</i>	48h EC50	0.32	Mokry and Hoagland 1990	LR (1)	CSI
<i>Daphnia magna</i>	48h EC50	0.37	Hooftman <i>et al.</i> 2002	RR	CSI
<i>Daphnia magna</i>	48h EC50	0.456	Handley <i>et al.</i> 1992a	LR (1)	CSI
<i>Daphnia magna</i>	48h LC50	0.99	Browne 1980	RL	CSI
<i>Daphnia magna</i>	48h EC50	1.6	Surprenant 1983	RR	UCD,CSI
<i>Enallagma/Ishnura</i>	24h LC50	1.1	Siegfried 1993	RL (5)	UCD,CSI
<i>Gammarus pulex</i>	48h LC50	0.11	Hooftman <i>et al.</i> 2002	RR	CSI
Heptageniidae	24h LC50	2.3	Siegfried 1993	RL (2,5)	UCD,CSI
<i>Hexagenia</i> sp.	48h LC50	0.39	Hooftman <i>et al.</i> 2002	RR	CSI
<i>Hyalella azteca</i>	96h LC50	0.0060	Weston & Jackson 2009	RR	UCD
<i>Hyalella azteca</i>	96h LC50	0.0093	Anderson <i>et al.</i> 2006	RR	UCD
<i>Hydrophilus</i> spp.	24h LC50	5.4	Siegfried 1993	RL (5)	UCD,CSI
<i>Hydropsyche/Cheumatopsyche</i>	24h LC50	7.2	Siegfried 1993	RL (5)	UCD,CSI
<i>Lepomis macrochirus</i>	96h LC50	0.26	Surprenant 1985b	RR	CSI
<i>Lepomis macrochirus</i>	96h LC50	0.35	Hoberg 1983a	RR	UCD
<i>Oncorhynchus mykiss</i>	76d MATC	0.019	Surprenant & Yarko 1985	RR	CSI
<i>Oncorhynchus mykiss</i>	96h LC50	0.1	Surprenant 1985c	RR	CSI
<i>Oncorhynchus mykiss</i>	96h LC50	0.15	Hoberg 1983b	RR	UCD
<i>Oncorhynchus mykiss</i>	96h LC50	0.91	Thompson 1985	LR (1)	CSI
<i>Oncorhynchus mykiss</i>	96h LC50	2.4	Handley <i>et al.</i> 1992b	LR (1)	CSI
<i>Pimephales promelas</i>	92d MATC	0.06	McAllister 1988	RR	UCD
<i>Pimephales promelas</i>	96h LC50	0.21	McAllister 1988	RR	UCD
<i>Pimephales promelas</i>	96h LC50	0.78	Guy 2000b	RR	UCD
<i>Procladius</i> sp.	48h LC50	0.0843	Anderson <i>et al.</i> 2006	RR	UCD
<i>Simulium vittatum</i>	24h LC50	1.3	Siegfried 1993	RL (5)	UCD,CSI
<i>Thamnocephalus platyurus</i>	24h LC50	5.7	Hooftman <i>et al.</i> 2002	RR	CSI
Trichoptera	48h LC50	0.18	Hooftman <i>et al.</i> 2002	RR	CSI

Appendix B. Study Evaluation Forms

Relevance/Usability Rating

Study: Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands.

Parameter	Score		Comment
Acceptable standard (or equivalent) method used	(10)	10	OECD 202, EU C.2
Endpoint linked to survival/growth/reproduction	(15)	15	
Freshwater	(15)	15	
Chemical \geq 80% pure	(15)	15	
Species is in a family that resides in North America	(15)	15	
Toxicity value calculated or calculable (e.g., LC50)	(15)	15	
Controls described (i.e., solvent, dilution water, etc.)	(7.5)	7.5	
Control response reported and meets acceptability requirements	(7.5)	7.5	
Total	(100)	100	

Other notes:

Toxicity Data Summary

Daphnia magna.
Bifenthrin

Study: Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands.

Relevance
Score: 100
Rating: R

Reliability
Score: 91.5
Rating: R

Reference	Hooftman <i>et al.</i> 2002	<i>Daphnia magna</i>
Parameter	Value	Comment
Test method cited	OECD 202, EU C.2	
Phylum	Arthropoda	
Class	Crustacea	
Order	Cladocera	
Family	Daphnidae	
Genus	<i>Daphnia</i>	
Species	<i>magna</i>	
Family in North America?	Yes	
Age/size at start of test/growth phase	<24 h	
Source of organisms	Laboratory culture	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	Yes	24 h, 48 h
Effect 1	Mobility	
Control response 1	100%	
Temperature	19.8	
Test type	Static	
Photoperiod/light intensity	16h light/8 h dark	
Dilution water	DSWL-E	Prepared from ground water
pH	7.9-8.1	
Hardness	213 mg/L as CaCO ₃	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	≥ 8.9 mg/L	
Feeding	No	
Purity of test substance	93.8%	
Concentrations measured?	Yes	In 3 test concentrations
Measured is what % of nominal?	105%	average for 2 concentrations at initiation and termination

Reference	Hoofman <i>et al.</i> 2002	<i>Daphnia magna</i>
Parameter	Value	Comment
Chemical method documented?	Yes	GC-ECD
Concentration of carrier (if any) in test solutions	0.1 mL/L, tert-butyl alcohol	
Concentration 1 Nom/Meas (µg/L)	0.018 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 2 Nom/Meas (µg/L)	0.056 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 3 Nom/Meas (µg/L)	0.18 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 4 Nom/Meas (µg/L)	0.56 µg/L (nominal), 0.33 µg/L (mean measured)	4 reps, 5 individuals/rep
Concentration 5 Nom/Meas (µg/L)	1.8 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 6 Nom/Meas (µg/L)	5.6 µg/L (nominal) 3.6 µg/L (mean measured)	4 reps, 5 individuals/rep
Control		4 reps, 5 individuals/rep
EC50	0.37 (0.25-0.54) µg/L	Kooijman
NOEC	0.056 µg/L	
LOEC	0.18 µg/L	
MATC	0.10 µg/L	
% of control at NOEC	100%	
% of control at LOEC	60%	

Reliability points taken off for:

Documentation: Alkalinity (2), Conductivity (2), Hypothesis tests (6)

Acceptability: Organisms randomly assigned (1), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests MSD (1)

Toxicity Data Summary

Ceriodaphnia dubia.

Bifenthrin

Study: Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands.

Relevance

Score: 100

Rating: R

Reliability

Score: 89.5

Rating: R

Reference	Hooftman <i>et al.</i> 2002	<i>Ceriodaphnia dubia</i>
Parameter	Value	Comment
Test method cited	OECD 202, EU C.2	
Phylum	Arthropoda	
Class	Crustacea	
Order	Cladocera	
Family	Daphniidae	
Genus	<i>Ceriodaphnia</i>	
Species	<i>dubia</i>	
Family in North America?	Yes	
Age/size at start of test/growth phase	<24 h	
Source of organisms	Cysts, commercial supplier	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mobility	
Control response 1	100%	
Temperature	24.3-24.4	
Test type	Static	
Photoperiod/light intensity	16h light/8 h dark	
Dilution water	DSWL-E	Prepared from ground water
pH	8.0-8.1	
Hardness	213 mg/L as CaCO ₃	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	≥ 7.9 mg/L	
Feeding	No	
Purity of test substance	93.8%	
Concentrations measured?	Yes	In 3 test concentrations
Measured is what % of nominal?	77%	average for 3 concentrations at initiation and termination

Reference	Hooftman <i>et al.</i> 2002	<i>Ceriodaphnia dubia</i>
Parameter	Value	Comment
Chemical method documented?	Yes	GC-ECD
Concentration of carrier (if any) in test solutions	0.1 mL/L, tert-butyl alcohol	
Concentration 1 Nom/Meas (µg/L)	0.056 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 2 Nom/Meas (µg/L)	0.18 µg/L (nominal) 0.15 (mean measured)	4 reps, 5 individuals/rep
Concentration 3 Nom/Meas (µg/L)	0.56 µg/L (nominal), 0.32 µg/L (mean measured)	4 reps, 5 individuals/rep
Concentration 4 Nom/Meas (µg/L)	1.8 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 5 Nom/Meas (µg/L)	5.6 µg/L (nominal) 6.2 µg/L (mean measured)	4 reps, 5 individuals/rep
Control		4 reps, 5 individuals/rep
EC50	0.40 (0.29-0.56) µg/L	Kooijman; based on nominal concentrations
NOEC	0.056 µg/L	
LOEC	0.18 µg/L	
MATC	0.10 µg/L	
% of control at NOEC	100%	
% of control at LOEC	75%	

Reliability points taken off for:

Documentation: Alkalinity (2), Conductivity (2), Hypothesis tests (6)

Acceptability: Measured within 20% of nominal (4), Organisms randomly assigned (1), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests MSD (1)

Toxicity Data Summary

Gammarus pulex
Bifenthrin

Study: Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands.

Relevance
Score: 100
Rating: R

Reliability
Score: 91.5
Rating: R

Reference	Hooftman <i>et al.</i> 2002	<i>Gammarus pulex</i>
Parameter	Value	Comment
Test method cited	OECD 202, EU C.2	
Phylum	Arthropoda	
Class	Crustacea	
Order	Amphipoda	
Family	Gammaridae	
Genus	<i>Gammarus</i>	
Species	<i>pulex</i>	
Family in North America?	Yes	
Age/size at start of test/growth phase	1.45 ± 0.085 cm	
Source of organisms	Commercial supplier	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	Yes	24 h, 48 h
Effect 1	Mobility	
Control response 1	100% (control), 95% (solvent control)	
Temperature	19.8	
Test type	Static	
Photoperiod/light intensity	16h light/8 h dark	
Dilution water	DSWL-E	Prepared from ground water
pH	7.8-8.0	
Hardness	213 mg/L as CaCO ₃	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	≥ 7.9 mg/L	
Feeding	No	
Purity of test substance	93.8%	
Concentrations measured?	Yes	In 3 test concentrations
Measured is what % of nominal?	80%	average for highest concentration at initiation and termination

Reference	Hooftman <i>et al.</i> 2002	<i>Gammarus pulex</i>
Parameter	Value	Comment
Chemical method documented?	Yes	GC-ECD
Concentration of carrier (if any) in test solutions	0.1 mL/L, tert-butyl alcohol	
Concentration 1 Nom/Meas (µg/L)	0.0032 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 2 Nom/Meas (µg/L)	0.010 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 3 Nom/Meas (µg/L)	0.032 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 4 Nom/Meas (µg/L)	0.1 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 5 Nom/Meas (µg/L)	0.32 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 6 Nom/Meas (µg/L)	1.0 µg/L (nominal) 0.75 µg/L (mean measured)	4 reps, 5 individuals/rep
Control		4 reps, 5 individuals/rep
LC50	0.11 (0.087-0.139) µg/L	Kooijman; based on nominal concentrations
NOEC	0.032 µg/L	
LOEC	0.1 µg/L	
MATC	0.057 µg/L	
% of control at NOEC	100%	
% of control at LOEC	55%	

Reliability points taken off for:

Documentation: Alkalinity (2), Conductivity (2), Hypothesis tests (6)

Acceptability: Organisms randomly assigned (1), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests MSD (1)

Toxicity Data Summary

Hexagenia sp.
Bifenthrin

Study: Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands.

Relevance
Score: 100
Rating: R

Reliability
Score: 89.5
Rating: R

Reference	Hooftman <i>et al.</i> 2002	<i>Hexagenia</i> sp.
Parameter	Value	Comment
Test method cited	OECD 202, EU C.2	
Phylum	Arthropoda	
Class	Insecta	
Order	Ephemeroptera	
Family	Ephemeridae	
Genus	<i>Hexagenia</i>	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	ca. 4 mm	
Source of organisms	Commercial supplier	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	Yes	24 h, 48 h
Effect 1	Mobility	
Control response 1	100%	
Temperature	20.0-20.2	
Test type	Static	
Photoperiod/light intensity	16h light/8 h dark	
Dilution water	DSWL-E	Prepared from ground water
pH	8.1-8.2	
Hardness	213 mg/L as CaCO ₃	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	≥ 8.0 mg/L	
Feeding	No	
Purity of test substance	93.8%	
Concentrations measured?	Yes	In 3 test concentrations
Measured is what % of nominal?	71%	average at initiation and termination
Chemical method documented?	Yes	GC-ECD

Reference	Hooftman <i>et al.</i> 2002	<i>Hexagenia</i> sp.
Parameter	Value	Comment
Concentration of carrier (if any) in test solutions	0.1 mL/L, tert-butyl alcohol	
Concentration 1 Nom/Meas (µg/L)	0.056 µg/L (nominal)	2 reps, 5 individuals/rep
Concentration 2 Nom/Meas (µg/L)	0.18 µg/L (nominal) 0.15 µg/L (mean measured)	2 reps, 5 individuals/rep
Concentration 3 Nom/Meas (µg/L)	0.56 µg/L (nominal) 0.36 µg/L (mean measured)	2 reps, 5 individuals/rep
Concentration 4 Nom/Meas (µg/L)	1.8 µg/L (nominal)	2 reps, 5 individuals/rep
Concentration 5 Nom/Meas (µg/L)	5.6 µg/L (nominal) 3.1 µg/L (mean measured)	2 reps, 5 individuals/rep
Control		2 reps, 5 individuals/rep
LC50	0.55 (0.35-0.88) µg/L	Kooijman; based on nominal concentrations
NOEC	0.056 µg/L	
LOEC	0.18 µg/L	
MATC	0.10 µg/L	
% of control at NOEC	100%	
% of control at LOEC	80%	

Reliability points taken off for:

Documentation: Alkalinity (2), Conductivity (2), Hypothesis tests (6)

Acceptability: Measured within 20% of nominal (4), Organisms randomly assigned (1), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests MSD (1)

Toxicity Data Summary

Thamnocephalus platyurus
Bifenthrin

Study: Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands.

Relevance

Score: 100

Rating: R

Reliability

Score: 91.5

Rating: R

Reference	Hooftman <i>et al.</i> 2002	<i>Thamnocephalus platyurus</i>
Parameter	Value	Comment
Test method cited	OECD 202, EU C.2	
Phylum	Arthropoda	
Class	Crustacea	
Order	Anostraca	
Family	Thamnocephalidae	
Genus	<i>Thamnocephalus</i>	
Species	<i>platyurus</i>	
Family in North America?	Yes	
Age/size at start of test/growth phase	<24 h	
Source of organisms	Commercial supplier	Supplied as cysts
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mobility	
Control response 1	100%	
Temperature	23.7-24.4	
Test type	Static	
Photoperiod/light intensity	16h light/8 h dark	
Dilution water	DSWL-E	Prepared from ground water
pH	8.1-8.2	
Hardness	213 mg/L as CaCO ₃	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	≥ 8.1 mg/L	
Feeding	No	
Purity of test substance	93.8%	
Concentrations measured?	Yes	In 3 test concentrations
Measured is what % of nominal?	105%	average at initiation and termination

Reference	Hooftman <i>et al.</i> 2002	<i>Thamnocephalus platyurus</i>
Parameter	Value	Comment
Chemical method documented?	Yes	GC-ECD
Concentration of carrier (if any) in test solutions	0.1 mL/L, tert-butyl alcohol	
Concentration 1 Nom/Meas (µg/L)	0.032 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 2 Nom/Meas (µg/L)	0.056 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 3 Nom/Meas (µg/L)	0.18 µg/L (nominal) 0.20 µg/L (mean measured)	4 reps, 5 individuals/rep
Concentration 4 Nom/Meas (µg/L)	0.56 µg/L (nominal) 0.58 µg/L (mean measured)	4 reps, 5 individuals/rep
Concentration 5 Nom/Meas (µg/L)	1.8 µg/L (nominal)	4 reps, 5 individuals/rep
Concentration 6 Nom/Meas (µg/L)	5.6 µg/L (nominal) 4.4 µg/L (mean measured)	4 reps, 5 individuals/rep
Control		4 reps, 5 individuals/rep
LC50	5.7 (1.6-20) µg/L	Kooijman; based on nominal concentrations
NOEC	0.032 µg/L	
LOEC	0.056 µg/L	
MATC	0.042 µg/L	
% of control at NOEC	100%	
% of control at LOEC	90%	

Reliability points taken off for:

Documentation: Alkalinity (2), Conductivity (2), Hypothesis tests (6)

Acceptability: Organisms randomly assigned (1), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests MSD (1)

Toxicity Data Summary

Trichoptera
Bifenthrin

Study: Hooftman RN, Rooseboom-Reimers A, Verhoof LRCW. 2002. Static acute toxicity tests with the insecticide bifenthrin technical and six arthropod species. Study No. 01-2424/01. TNO Chemistry. Delft, The Netherlands.

Relevance

Score: 100

Rating: R

Reliability

Score: 87.5

Rating: R

Reference	Hooftman <i>et al.</i> 2002	Trichoptera
Parameter	Value	Comment
Test method cited	OECD 202, EU C.2	
Phylum	Arthropoda	
Class	Insecta	
Order	Trichoptera	
Family	NR	
Genus	NR	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	Not measured	
Source of organisms	Commercial supplier	
Have organisms been exposed to contaminants?	No	
Animals acclimated and disease-free?	Yes	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	48 h	
Data for multiple times?	Yes	24 h, 48 h
Effect 1	Mobility	
Control response 1	100%	
Temperature	19.8-19.9	
Test type	Static	
Photoperiod/light intensity	16h light/8 h dark	
Dilution water	DSWL-E	Prepared from ground water
pH	7.9-8.0	
Hardness	213 mg/L as CaCO ₃	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	≥ 6.3mg/L	
Feeding	No	
Purity of test substance	93.8%	
Concentrations measured?	Yes	In 3 test concentrations
Measured is what % of nominal?	81%	average at initiation and termination
Chemical method documented?	Yes	GC-ECD

Reference	Hoofman <i>et al.</i> 2002	Trichoptera
Parameter	Value	Comment
Concentration of carrier (if any) in test solutions	0.1 mL/L, tert-butyl alcohol	
Concentration 1 Nom/Meas (µg/L)	0.056 µg/L (nominal)	2 reps, 5 individuals/rep
Concentration 2 Nom/Meas (µg/L)	0.18 µg/L (nominal) 0.13 µg/L (mean measured)	2 reps, 5 individuals/rep
Concentration 3 Nom/Meas (µg/L)	0.56 µg/L (nominal) 0.41 µg/L (mean measured)	2 reps, 5 individuals/rep
Concentration 4 Nom/Meas (µg/L)	1.8 µg/L (nominal)	2 reps, 5 individuals/rep
Concentration 5 Nom/Meas (µg/L)	5.6 µg/L (nominal) 4.5 µg/L (mean measured)	2 reps, 5 individuals/rep
Control		2 reps, 5 individuals/rep
LC50	0.22 (0.16-0.31) µg/L	Kooijman; based on nominal concentrations
NOEC	0.056 µg/L	
LOEC	0.18 µg/L	
MATC	0.10 µg/L	
% of control at NOEC	100%	
% of control at LOEC	60%	

Reliability points taken off for:

Documentation: Organism size (5), Alkalinity (2), Conductivity (2), Hypothesis tests (6)

Acceptability: Organisms size (3), Organisms randomly assigned (1), Alkalinity (2), Conductivity (1), Random design (2), Hypothesis tests MSD (1)

Relevance/Usability Rating

Study: Siegfried BD. 1993. Comparative toxicity of pyrethroid insecticides to terrestrial and aquatic insects. *Environ Toxicol Chem* 12:1683-1689.

Parameter	Score		Comment
Acceptable standard (or equivalent) method used	(10)	0	No standard method cited
Endpoint linked to survival/growth/reproduction	(15)	15	
Freshwater	(15)	15	
Chemical \geq 80% pure	(15)	15	
Species is in a family that resides in North America	(15)	15	All collected in Nebraska
Toxicity value calculated or calculable (e.g., LC50)	(15)	15	
Controls described (i.e., solvent, dilution water, etc.)	(7.5)	7.5	Distilled water
Control response reported and meets acceptability requirements	(7.5)	7.5	No defined requirements; 14% mortality in <i>Simulium vittatum</i> , 16% in Heptageniidae, <10% in other species
Total	(100)	90	

Other notes:

Toxicity Data Summary

Enallagma sp./*Ishnura* sp.
Bifenthrin

Study: Siegfried BD. 1993. Comparative toxicity of pyrethroid insecticides to terrestrial and aquatic insects. *Environ Toxicol Chem* 12:1683-1689.

Relevance

Score: 90

Rating: R

Reliability

Score: 78.0

Rating: L

Reference	Siegfried 1993	<i>Enallagma/Ishnura</i>
Parameter	Value	Comment
Test method cited	NR	
Phylum	Arthropoda	
Class	Insecta	
Order	Odonata	
Family	Coenagrionidae	
Genus	<i>Enallagma</i> and <i>Ishnura</i>	
Species	sp.	
Family in North America?	Yes	
Age/size at start of test/growth phase	Nymph (10-15 mm)	
Source of organisms	Killdeer L., Lancaster Co., NE	
Have organisms been exposed to contaminants?	No (unless exposed before field collection)	
Animals acclimated and disease-free?	Acclimated up to 72 h after collection; disease status unknown	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	< 10%	
Temperature	20°C	
Test type	Static	
Photoperiod/light intensity	Dark	
Dilution water	Distilled water	
pH	NR	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	NR	
Feeding	No	
Purity of test substance	94%	
Concentrations measured?	No	
Measured is what % of nominal?	NA	
Chemical method documented?	NA	
Concentration of carrier (if any) in test solutions	NA	No mention of carrier in static tests

Reference	Siegfried 1993	<i>Enallagma/ishnura</i>
Parameter	Value	Comment
Concentration 1 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 2 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 3 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 4 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Concentration 5 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Control	Distilled water	At least 3 reps, 5 or 10 individuals/rep
LC50 (95% conf limits)	1.1 (0.68-1.7)	Log-probit
ECx	NR	
NOEC	NR	
LOEC	NR	
MATC	NR	
% of control at NOEC	NR	
% of control at LOEC	NR	

Reliability points taken off for:

Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3)

Acceptability: Standard method (5), Meas. Conc. 20% Nom. (4), randomly assigned to reps (1), disease-free (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Dilution factor (2)

Toxicity Data Summary

Heptageniidae
Bifenthrin

Study: Siegfried BD. 1993. Comparative toxicity of pyrethroid insecticides to terrestrial and aquatic insects. *Environ Toxicol Chem* 12:1683-1689.

Relevance

Score: 90

Rating: R

Reliability

Score: 73.5

Rating: L

Reference	Siegfried 1993	Heptageniidae
Parameter	Value	Comment
Test method cited	NR	
Phylum	Arthropoda	
Class	Insecta	
Order	Ephemeroptera	
Family	Heptageniidae	
Genus	NR	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	Nymph (8-12 mm)	
Source of organisms	Bear Creek, Gage Co., NE	
Have organisms been exposed to contaminants?	No (unless exposed before field collection)	
Animals acclimated and disease-free?	Acclimated up to 72 h after collection; disease status unknown	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	16%	
Temperature	20°C	
Test type	Static	
Photoperiod/light intensity	Dark	
Dilution water	Distilled water	
pH	NR	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	NR	
Feeding	No	
Purity of test substance	94%	
Concentrations measured?	No	
Measured is what % of nominal?	NA	
Chemical method documented?	NA	
Concentration of carrier (if any) in test solutions	NA	No mention of carrier in static tests

Reference	Siegfried 1993	Heptageniidae
Parameter	Value	Comment
Concentration 1 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 2 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 3 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 4 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Concentration 5 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Control	Distilled water	At least 3 reps, 5 or 10 individuals/rep
LC50 (95% conf limits)	2.3 (1.7-3.0)	Log-probit
ECx	NR	
NOEC	NR	
LOEC	NR	
MATC	NR	
% of control at NOEC	NR	
% of control at LOEC	NR	

Reliability points taken off for:

Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3)

Acceptability: Standard method (5), Control response (9), Meas. Conc. 20% Nom. (4), randomly assigned to reps (1), disease-free (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Dilution factor (2)

Toxicity Data Summary

Hydrophilus sp.
Bifenthrin

Study: Siegfried BD. 1993. Comparative toxicity of pyrethroid insecticides to terrestrial and aquatic insects. *Environ Toxicol Chem* 12:1683-1689.

Relevance

Score: 90

Rating: R

Reliability

Score: 78.0

Rating: L

Reference	Siegfried 1993	<i>Hydrophilus</i>
Parameter	Value	Comment
Test method cited	NR	
Phylum	Arthropoda	
Class	Insecta	
Order	Coleoptera	
Family	Hydrophilidae	
Genus	<i>Hydrophilus</i>	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	Adult	
Source of organisms	Killdeer L., Lancaster Co., NE	
Have organisms been exposed to contaminants?	No (unless exposed before field collection)	
Animals acclimated and disease-free?	Acclimated up to 72 h after collection; disease status unknown	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	< 10%	
Temperature	20°C	
Test type	Static	
Photoperiod/light intensity	Dark	
Dilution water	Distilled water	
pH	NR	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	NR	
Feeding	No	
Purity of test substance	94%	
Concentrations measured?	No	
Measured is what % of nominal?	NA	
Chemical method documented?	NA	
Concentration of carrier (if any) in test solutions	NA	No mention of carrier in static tests

Reference	Siegfried 1993	<i>Hydrophilus</i>
Parameter	Value	Comment
Concentration 1 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 2 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 3 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 4 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Concentration 5 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Control	Distilled water	At least 3 reps, 5 or 10 individuals/rep
LC50 (95% conf limits)	5.4 (3.9-7.7)	Log-probit
ECx	NR	
NOEC	NR	
LOEC	NR	
MATC	NR	
% of control at NOEC	NR	
% of control at LOEC	NR	

Reliability points taken off for:

Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3)

Acceptability: Standard method (5), Meas. Conc. 20% Nom. (4), randomly assigned to reps (1), disease-free (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Dilution factor (2)

Toxicity Data Summary

Hydropsyche/Cheumatopsyche
Bifenthrin

Study: Siegfried BD. 1993. Comparative toxicity of pyrethroid insecticides to terrestrial and aquatic insects. *Environ Toxicol Chem* 12:1683-1689.

Relevance

Score: 90

Rating: R

Reliability

Score: 78.0

Rating: L

Reference	Siegfried 1993	<i>Hydropsyche/Cheumatopsyche</i>
Parameter	Value	Comment
Test method cited	NR	
Phylum	Arthropoda	
Class	Insecta	
Order	Trichoptera	
Family	Hydropsychidae	
Genus	<i>Hydropsyche/Cheumatopsyche</i>	
Species	NR	
Family in North America?	Yes	
Age/size at start of test/growth phase	Larvae (8-10 mm)	
Source of organisms	Hanes Br., Lancaster Co., NE	
Have organisms been exposed to contaminants?	No (unless exposed before field collection)	
Animals acclimated and disease-free?	Acclimated up to 72 h after collection; disease status unknown	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	< 10%	
Temperature	20°C	
Test type	Static	
Photoperiod/light intensity	Dark	
Dilution water	Distilled water	
pH	NR	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	NR	
Feeding	No	
Purity of test substance	94%	
Concentrations measured?	No	
Measured % of nominal?	NA	
Chemical method documented?	NA	

Reference	Siegfried 1993	Hydropsyche/Cheumatopsyche
Parameter	Value	Comment
Concentration of carrier (if any) in test solutions	NA	No mention of carrier in static tests
Concentration 1 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 2 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 3 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 4 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Concentration 5 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Control	Distilled water	At least 3 reps, 5 or 10 individuals/rep
LC50 (95% conf limits)	7.2 (4.5-10)	Log-probit
ECx	NR	
NOEC	NR	
LOEC	NR	
MATC	NR	
% of control at NOEC	NR	
% of control at LOEC	NR	

Reliability points taken off for:

Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3)

Acceptability: Standard method (5), Meas. Conc. 20% Nom. (4), randomly assigned to reps (1), disease-free (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Dilution factor (2)

Toxicity Data Summary

Simulium vittatum
Bifenthrin

Study: Siegfried BD. 1993. Comparative toxicity of pyrethroid insecticides to terrestrial and aquatic insects. *Environ Toxicol Chem* 12:1683-1689.

Relevance

Score: 90

Rating: R

Reliability

Score: 73.5

Rating: L

Reference	Siegfried 1993	<i>Simulium vittatum</i>
Parameter	Value	Comment
Test method cited	NR	
Phylum	Arthropoda	
Class	Insecta	
Order	Diptera	
Family	Simuliidae	
Genus	<i>Simulium</i>	
Species	<i>vittatum</i>	
Family in North America?	Yes	
Age/size at start of test/growth phase	Larva (5-7 mm)	
Source of organisms	Hanes Br., Lancaster Co., NE	
Have organisms been exposed to contaminants?	No (unless exposed before field collection)	
Animals acclimated and disease-free?	Acclimated up to 72 h after collection; disease status unknown	
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	24 h	
Data for multiple times?	No	
Effect 1	Mortality	
Control response 1	14%	
Temperature	20°C	
Test type	Static	
Photoperiod/light intensity	Dark	
Dilution water	Distilled water	
pH	NR	
Hardness	NR	
Alkalinity	NR	
Conductivity	NR	
Dissolved Oxygen	NR	
Feeding	No	
Purity of test substance	94%	
Concentrations measured?	No	
Measured % of nominal?	NA	
Chemical method documented?	NA	
Concentration of carrier (if any) in test solutions	NA	No mention of carrier in static tests

Reference	Siegfried 1993	<i>Simulium vittatum</i>
Parameter	Value	Comment
Concentration 1 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 2 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 3 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep
Concentration 4 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Concentration 5 Nom/Meas (µg/L)	NR	At least 3 reps, 5 or 10 individuals/rep; "at least 3 concentrations"
Control	Distilled water	At least 3 reps, 5 or 10 individuals/rep
LC50 (95% conf limits)	7.2 (4.5-10)	Log-probit
ECx	NR	
NOEC	NR	
LOEC	NR	
MATC	NR	
% of control at NOEC	NR	
% of control at LOEC	NR	

Reliability points taken off for:

Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3)

Acceptability: Standard method (5), Control response (9), Meas. Conc. 20% Nom. (4), randomly assigned to reps (1), disease-free (1), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), Dilution factor (2)

Relevance/Usability Rating

Study: Wang C, Chen F, Zhang Q, Fang Z. 2009. Chronic toxicity and cytotoxicity of synthetic pyrethroid insecticide *cis*-bifenthrin. *J Environ Sci* 21:1710-1715.

Parameter	Score		Comment
Acceptable standard (or equivalent) method used	(10)	10	OECD 1998
Endpoint linked to survival/growth/reproduction	(15)	15	
Freshwater	(15)	15	
Chemical \geq 80% pure	(15)	15	
Species is in a family that resides in North America	(15)	15	
Toxicity value calculated or calculable (e.g., LC50)	(15)	15	
Controls described (i.e., solvent, dilution water, etc.)	(7.5)	7.5	
Control response reported and meets acceptability requirements	(7.5)	7.5	
Total	(100)	100	

Other notes:

Toxicity Data Summary

Daphnia magna
Bifenthrin

Study: Wang C, Chen F, Zhang Q, Fang Z. 2009. Chronic toxicity and cytotoxicity of synthetic pyrethroid insecticide *cis*-bifenthrin. *J Environ Sci* 21:1710-1715.

Relevance

Score: 100

Rating: R

Reliability

Score: 76.0

Rating: R

Reference	Wang <i>et al.</i> 2009	<i>Daphnia magna</i>
Parameter	Value	Comment
Test method cited	OECD 1998	
Phylum	Arthropoda	
Class	Crustacea	
Order	Cladocera	
Family	Daphnidae	
Genus	<i>Daphnia</i>	
Species	<i>magna</i>	
Family in North America?	Yes	
Age/size at start of test/growth phase	< 24 h	
Source of organisms	Laboratory culture	
Have organisms been exposed to contaminants?	No	Presumed
Animals acclimated and disease-free?	Yes	Presumed disease-free
Animals randomized?	NR	
Test vessels randomized?	NR	
Test duration	21 d	
Data for multiple times?	No	
Effect 1	Number of young/female	
Control response 1	91.6 (SD = 16.61)	
Effect 2	Average brood size	
Control response 2	7.5 (SD = 1.65)	
Effect 3	Number of first brood/female	
Control response 3	12.4 (SD = 3.60)	
Effect 4	Days to first brood	
Control response 4	6.2 (SD = 0.63)	
Effect 5	Longevity (d)	
Control response 5	20.5 (SD = 1.33)	
Effect 6	Length (cm)	
Control response 6	5.1 (SD = 0.29)	
Temperature	22 ± 1 °C	
Test type	Static, 48-h renewal	
Photoperiod/light intensity	12 h light:12 h dark	
Dilution water	M4 medium (OECD 1998)	
pH	NR	Cites OECD 1998
Hardness	NR	Cites OECD 1998

Reference	Wang <i>et al.</i> 2009	<i>Daphnia magna</i>
Parameter	Value	Comment
Alkalinity	NR	Cites OECD 1998
Conductivity	NR	Cites OECD 1998
Dissolved Oxygen	NR	Cites OECD 1998
Feeding	Yes, but not reported	<i>D. magna</i> are fed during chronic toxicity tests
Purity of test substance	99.5%	Purchased from Sigma
Concentrations measured?	No	
Measured is what % of nominal?	NA	
Chemical method documented?	No	
Concentration of carrier (if any) in test solutions	Ethanol \leq 0.008%	Meets acceptability criterion (0. 01%)
Concentration 1 Nom/Meas ($\mu\text{g/L}$)	0.005	10 reps, 1 individual/rep
Concentration 2 Nom/Meas ($\mu\text{g/L}$)	0.01	10 reps, 1 individual/rep
Concentration 3 Nom/Meas ($\mu\text{g/L}$)	0.02	10 reps, 1 individual/rep
Concentration 4 Nom/Meas ($\mu\text{g/L}$)	0.04	10 reps, 1 individual/rep
Concentration 5 Nom/Meas ($\mu\text{g/L}$)	0.08	10 reps, 1 individual/rep
Control	0	10 reps, 1 individual/rep
EC50 ($\mu\text{g/L}$)	0.031 (longevity) 0.019 (reproduction)	Non-linear regression
NOEC ($\mu\text{g/L}$)	0.01 (longevity, number of first brood/female, average brood size, number of young/female) 0.02 (days to first brood) 0.04 (length)	One-way ANOVA (OriginLab software) $p < 0.05$ MSD not reported
LOEC ($\mu\text{g/L}$)	0.02, 0.04, and > 0.04 for the endpoints listed above	
MATC ($\mu\text{g/L}$)	0.014	Most sensitive endpoints: longevity, number of first brood/female, average brood size, young/female
% of control at NOEC	94% (longevity) 98% (days to first brood) 90% (first brood/female) 95% (average brood size) 92% (young/female) 75% (length)	
% of control at LOEC	81% (longevity) 126% (days to first brood) 72% (first brood/female) 69% (average brood size) 52% (young/female)	

Reliability points taken off for:

Documentation: Measured concentrations (3), Hardness (2), Alkalinity (2), Dissolved oxygen (4), Conductivity (2), pH (3); MSD (2) (total 18)

Acceptability: Solvent control (6), Meas. Conc. 20% Nom. (4), Randomly assigned to reps (1), Feeding (3), Hardness (2), Alkalinity (2), Dissolved oxygen (6), Conductivity (1), pH (2), Random design (2), MSD (1) (total 30)